CLAIMS

What is claimed is:

1. A production schedule creation device, comprising:

a production simulator that simulates a production process expressing a production state and a production constraint of the production process;

a mathematical expression model holding device that holds a mathematical expression model which is created by acquiring information relating to creation of a production schedule to which attention is paid, and is a mathematical expression model expressing the production state and the production constraint of the above described production process in a mathematical expression; and

an optimization calculation device that performs optimization calculation processing by using a predetermined evaluation function for the above described mathematical expression model, and calculates a production instruction for said production simulator,

wherein the production instruction obtained by said optimization calculation device is supplied to said production simulator to cause it to execute simulation, an instruction to perform optimization calculation is output to said optimization calculation device from said production simulator whenever a new event occurs, and thereby said

production simulator and said optimization calculation device are linked to each other to create the production schedule in the above described production process.

2. A production schedule creation device, comprising:

a production simulator that simulates a production process expressing a production state and a production constraint of the production process;

a mathematical expression model holding device that holds a mathematical expression model which uses a state equation created by acquiring information relating to creation of a production schedule to which attention is paid, and is a mathematical expression model expressing the production state and the production constraint of the above described production process in a mathematical expression; and

an optimization calculation device that performs optimization calculation processing by using a predetermined evaluation function for the above described mathematical expression model to calculate a production instruction for said production simulator,

wherein the production schedule in the above described production process is created from a simulation result obtained by repeating processing of calculating a feedback gain by the above described optimization calculation processing, calculating the production instruction by using the feedback gain and

the production state to supply the production instruction to said production simulator to proceed with simulation, obtaining a new production state, and calculating a new production instruction based on the new production state.

3. The production schedule creation device according to claim 2,

wherein said production simulator is a production simulator of a discrete system.

4. The production schedule creation device according to claim 3,

wherein said production simulator of the discrete system constructs a simulator by using a graph model, and the above described state equation is a state equation of the graph model.

5. The production schedule creation device according to claim 4,

wherein when the feedback gain is calculated by the above described optimization calculation processing, and the production instruction is calculated by using the feedback gain and the production state, an operation vector for a transfer operation node of each of products is obtained from the feedback gain and a state vector expressing an in-process product progress state, and thereafter, in accordance with sequence of products obtaining larger manipulative variables in positive value of the obtained operation vectors, an operation is made for each transfer operation node to transfer each of the

products by a transferable number.

6. The production schedule creation device according to claim 3,

wherein said production simulator of the discrete system constructs a simulator by using a graph model, and the above described state equation is a state equation using an incidence matrix and a transition matrix which are expressed in accordance with piecewise time delays proportional to processing times.

7. The production schedule creation device according to claim 6,

wherein when the feedback gain is calculated by the above described optimization calculation processing, and the production instruction is calculated by using the feedback gain and the production state, an operation vector for a transfer operation node of each of products is obtained from the feedback gain and a state vector expressing an in-process product progress state, and thereafter, in accordance with sequence of the products obtaining larger manipulative variables in positive value of the obtained operation vectors, an operation is made for each transfer operation node to transfer each of the products by a transferable number.

8. The production schedule creation device according to claim 3,

wherein said production simulator of the discrete system constructs a simulator by using a Petri net

model, and the above described state equation is a state equation of the Petri net model.

9. The production schedule creation device according to claim 8,

wherein when the feedback gain is calculated by the above described optimization calculation processing, and the production instruction is calculated by using the feedback gain and the production state, an operation vector for a transfer operation node of each of products is obtained from the feedback gain and a state vector expressing an in-process product progress state, and thereafter, in accordance with sequence of products obtaining larger manipulative variables in positive value of the obtained operation vectors, an operation is made for each transfer operation node to transfer each of the products by a transferable number.

10. The production schedule creation device according to claim 3,

wherein said production simulator of the discrete system constructs a simulator by using a Petri net model, and the above described state equation is a state equation using an incidence matrix and a transition matrix which are expressed in accordance with piecewise time delays proportional to processing times.

11. The production schedule creation device according to claim 10,

wherein when the feedback gain is calculated by

the above described optimization calculation processing, and the production instruction is calculated by using the feedback gain and the production state, an operation vector for a transfer operation node of each of products is obtained from the feedback gain and a state vector expressing an in-process product progress state, and thereafter, in accordance with sequence of products obtaining larger manipulative variables in positive value of the obtained operation vectors, an operation is made for each transfer operation node to transfer each of the products by a transferable number.

12. The production schedule creation device according to claim 2,

wherein the above described optimization calculation processing utilizes linear quadratic control, and calculates the above described feedback gain to minimize an evaluation function expressed by using a predetermined evaluation matrix.

13. A production schedule creation device, comprising:

a production simulator that simulates a production process expressing a production state and a production constraint of the production process;

a mathematical expression model holding device that holds a mathematical expression model which is created by acquiring information relating to creation of a production schedule to which attention is paid, with a time period previously set from a schedule

creation starting time of the above described production process (schedule creation time period) as a target, and is a mathematical expression model expressing the production state and the production constraint of the above described production process in a mathematical expression; and

an optimization calculation device that performs optimization calculation processing by using a predetermined evaluation function for the above described mathematical expression model, and calculates a production instruction for said production simulator,

wherein the production schedule in the above described production process is created from a simulation result obtained by repeating processing of calculating the production instruction for a time period previously set from present time by the above described optimization calculation processing (instruction calculation time period) to supply the production instruction to said production simulator, executing simulation for only a previously set time period (simulation time period) to determine a production schedule for a previously set time period (schedule determination time period), and setting a date and time immediately after the above described determined time period as a new schedule creation starting time and time to formulate a production schedule.

14. The production schedule creation device

according to claim 13,

wherein said production simulator is a production simulator of a discrete system.

15. The production schedule creation device according to claim 14,

wherein said production simulator of the discrete system is a simulator expressing the above described production process in a discrete event model, and detects a present production state and production constraint from said simulator when an event occurs.

16. The production schedule creation device according to claim 13,

wherein the above described time period previously set from the schedule creation starting time is for a previously set target time period.

17. The production schedule creation device according to claim 13,

wherein the above described time period previously set from the schedule creation starting time is a time period set to be a predetermined divided range from a time of occurrence of the above described event as a prediction range of a future production state.

18. The production schedule creation device according to claim 13,

wherein the mathematical expression model created by acquiring the information relating to creation of the above described production schedule to which attention is paid is constructed for products, a

transportion means, relationship of operation groups accompanying processing of equipment, and a constraint.

19. The production schedule creation device according to claim 13,

wherein the mathematical expression model created by acquiring the information relating to creation of the above described production schedule to which attention is paid is a mathematical expression model composed of the above described detected present production state and production constraint.

20. The production schedule creation device according to claim 13,

wherein said optimization calculation device performs the optimization calculation processing by using a previously set evaluation function.

21. The production schedule creation device according to claim 13,

wherein said optimization calculation device performs the optimization calculation processing by using a previously set linear evaluation function.

22. The production schedule creation device according to claim 13,

wherein said optimization calculation device creates the above described production schedule as an optimization or sub-optimization problem.

23. The production schedule creation device according to claim 13,

wherein said optimization calculation device

obtains at least an optimum occurring event and its time of occurrence within the above described set prediction range.

24. The production schedule creation device according to claim 13,

wherein production simulate processing of simulating an operation/situation of all or a part of the above described products, transportion means, relationship of operation groups accompanying processing of equipment, and a constraint, based on the calculation result of said optimization calculation device, and

production schedule determining processing of adopting and determining a production schedule for a previously set determination time period out of the production schedule obtained by the above described production processing

are performed to determine the production schedule for the above described previously set time period (schedule determination time period).

25. The production schedule creation device according to claim 13,

wherein said production/production simulator proceeds with simulation and determines the production schedule for the above described previously set time period (schedule creation time period).

26. The production schedule creation device according to claim 13,

wherein processing of performing optimization calculation by separating a future prediction range from the occurrence event of the above described event, and supplying the result to said simulator to advance event occurrence time is repeatedly performed every time an event occurs, and sequence of occurrence of a series of events and event occurrence times obtained from a result of the repeated calculation for each of the above described prediction ranges are determined as the production schedule.

27. The production schedule creation device according to claim 23,

wherein a series of processing of determining a production schedule of a new determination time period from the above described new schedule creation starting time and date is performed for each of new schedule creation starting times and times which are set in sequence, by

mathematical expression model obtaining processing of setting a date and time immediately after the determination time period of the production schedule determined by the above described production schedule determination processing elapses as the new schedule creation starting time and time, and obtaining a solution for a mathematical expression model based on a new mathematical expression model constructed by processing of constructing the above described mathematical expression model based on the

production schedule already determined by the above described production schedule determination processing,

production simulate processing of simulating an operation/situation of a manufacturing process/conveyance based on the solution for the mathematical expression model obtained by the above described mathematical model obtaining processing, and

production determination processing of adopting only a production schedule of a previously set determination time period out of the production schedule obtained by the above described production simulate processing, and determining the production schedule.

28. The production schedule creation device according to claim 14,

wherein the above described production simulator of the discrete system is constructed by using a Petri net model.

29. The production schedule creation device according to claim 13,

wherein said optimization calculation device uses an LP (linear programming).

30. A method for creating a production schedule by a production schedule creation device having a production simulator that simulates a production process expressing a production state and a production constraint of the production process, a

mathematical expression model holding device that holds a mathematical expression model which is created by acquiring information relating to creation of a production schedule to which attention is paid, and is a mathematical expression model expressing the production state and the production constraint of the above described production process in a mathematical expression, and an optimization calculation device that performs optimization calculation processing by using a predetermined evaluation function for the above described mathematical expression model, and calculates a production instruction for the above described production simulator,

wherein the production instruction obtained by the above described optimization calculation device is supplied to the above described production simulator to cause it to execute simulation, an instruction to perform optimization calculation is output to the above described optimization calculation device from the above described production simulator whenever a new event occurs, and thereby the above described production simulator and the above described optimization calculation device are linked to each other to create the production schedule in the above described production process.

31. A method for creating a production schedule by a production schedule creation device having a production simulator that simulates a production process expressing a production state and a

production constraint of the production process, a mathematical expression model holding device that holds a mathematical expression model which uses a state equation created by acquiring information relating to creation of a production schedule to which attention is paid, and is a mathematical expression model expressing the production state and the production constraint of the above described production process in a mathematical expression, and an optimization calculation device that performs optimization calculation processing by using a predetermined evaluation function for the above described mathematical expression model to calculate a production instruction for the above described production simulator,

wherein the production schedule in the above described production process is created from a simulation result obtained by repeating processing of calculating a feedback gain by the above described optimization calculation processing, calculating the production instruction by using the feedback gain and the production state to supply the production instruction to the above described production simulator to proceed with simulation, obtaining a new production state, and calculating a new production instruction based on the new production state.

32. A method for creating a production schedule by a production schedule creation device having a production simulator that simulates a production

process expressing a production state and a production constraint of the production process, a mathematical expression model holding device that holds a mathematical expression model which is created by acquiring information relating to creation of a production schedule to which attention is paid, with a time period previously set from a schedule creation starting time of the above described production process (schedule creation time period) as a target, and is a mathematical expression model expressing the production state and the production constraint of the above described production process in a mathematical expression, and an optimization calculation device that performs optimization calculation processing by using a predetermined evaluation function for the above described mathematical expression model, and calculates a production instruction for the above described production simulator,

wherein the production schedule in the above described production process is created from a simulation result obtained by repeating processing of calculating the production instruction for a time period previously set from present time by the above described optimization calculation processing (instruction calculation time period) to supply the production instruction to the above described production simulator, executing simulation for only the previously set time period (simulation time

period) to determine a production schedule for a previously set time period (schedule determination time period), and setting a date and time immediately after the above described determined time period as a new schedule creation starting time and time to formulate a production schedule.

33. A computer program causing a computer to realize functions as a production simulator that simulates a production process expressing a production state and a production constraint of the production process, a mathematical expression model holding device that holds a mathematical expression model which is created by acquiring information relating to creation of a production schedule to which attention is paid, and is a mathematical expression model expressing the production state and the production constraint of the above described production process in a mathematical expression, and an optimization calculation device that performs optimization calculation processing by using a predetermined evaluation function for the above described mathematical expression model, and calculates a production instruction for the above described production simulator,

wherein the production instruction obtained by the above described optimization calculation device is supplied to the above described production simulator to cause it to execute simulation, an instruction to perform optimization calculation is

output to the above described optimization calculation device from the above described production simulator whenever a new event occurs, and thereby the above described production simulator and the above described optimization calculation device are linked to each other to create the production schedule in the above described production process.

34. A computer-readable recording medium recording a computer program causing a computer to realize functions as a production simulator that simulates a production process expressing a production state and a production constraint of the production process, a mathematical expression model holding device that holds a mathematical expression model which is created by acquiring information relating to creation of a production schedule to which attention is paid, and is a mathematical expression model expressing the production state and the production constraint of the above described production process in a mathematical expression, and an optimization calculation device that performs optimization calculation processing by using a predetermined evaluation function for the above described mathematical expression model, and calculates a production instruction for the above described production simulator,

wherein the production instruction obtained by the above described optimization calculation device is supplied to the above described production

simulator to cause it to execute simulation, an instruction to perform optimization calculation is output to the above described optimization calculation device from the above described production simulator whenever a new event occurs, and thereby the above described production simulator and the above described optimization calculation device are linked to each other to create the production schedule in the above described production process.

35. A computer program causing a computer to realize functions as a production simulator that simulates a production process expressing a production state and a production constraint of the production process, a mathematical expression model holding device that holds a mathematical expression model which uses a state equation created by acquiring information relating to creation of a production schedule to which attention is paid, and is a mathematical expression model expressing the production state and the production constraint of the above described production process in a mathematical expression, and an optimization calculation device that performs optimization calculation processing by using a predetermined evaluation function for the above described mathematical expression model to calculate a production instruction for the above described production simulator,

wherein the production schedule in the above described production process is created from a

simulation result obtained by repeating processing of calculating a feedback gain by the above described optimization calculation processing, calculating the production instruction by using the feedback gain and the production state to supply the production instruction to the above described production simulator to proceed with simulation, obtaining a new production state, and calculating a new production instruction based on the new production state.

36. A computer-readable recording medium recording a computer program causing a computer to realize functions as a production simulator that simulates a production process expressing a production state and a production constraint of the production process, a mathematical expression model holding device that holds a mathematical expression model which uses a state equation created by acquiring information relating to creation of a production schedule to which attention is paid, and is a mathematical expression model expressing the production state and the production constraint of the above described production process in a mathematical expression, and an optimization calculation device that performs optimization calculation processing by using a predetermined evaluation function for the above described mathematical expression model to calculate a production instruction for the above described production simulator,

wherein the production schedule in the above

described production process is created from a simulation result obtained by repeating processing of calculating a feedback gain by the above described optimization calculation processing, calculating the production instruction by using the feedback gain and the production state to supply the production instruction to the above described production simulator to proceed with simulation, obtaining a new production state, and calculating a new production instruction based on the new production state.

37. A computer program causing a computer to realize functions as a production simulator that simulates a production process expressing a production state and a production constraint of the production process, a mathematical expression model holding device that holds a mathematical expression model which is created by acquiring information relating to creation of a production schedule to which attention is paid, with a time period previously set from a schedule creation starting time of the above described production process (schedule creation time period) as a target, and is a mathematical expression model expressing the production state and the production constraint of the above described production process in a mathematical expression, and an optimization calculation device that performs optimization calculation processing by using a predetermined evaluation function for the above described mathematical expression model, and

calculates a production instruction for the above described production simulator,

wherein the production schedule in the above described production process is created from a simulation result obtained by repeating processing of calculating the production instruction for a time period previously set from present time by the above described optimization calculation processing (instruction calculation time period) to supply the production instruction to the above described production simulator, executing simulation for only a previously set time period (simulation time period) to determine a production schedule for a previously set time period (schedule determination time period), and setting a date and time immediately after the above described determined time period as a new schedule creation starting time and time to formulate a production schedule.

38. A computer-readable recording medium recording a computer program causing a computer to realize functions as a production simulator that simulates a production process expressing a production state and a production constraint of the production process, a mathematical expression model holding device that holds a mathematical expression model which is created by acquiring information relating to creation of a production schedule to which attention is paid, with a time period previously set from a schedule creation starting time

of the above described production process (schedule creation time period) as a target, and is a mathematical expression model expressing the production state and the production constraint of the above described production process in a mathematical expression, and an optimization calculation device that performs optimization calculation processing by using a predetermined evaluation function for the above described mathematical expression model, and calculates a production instruction for the above described production simulator,

wherein the production schedule in the above described production process is created from a simulation result obtained by repeating processing of calculating the production instruction for a time period previously set from present time by the above described optimization calculation processing (instruction calculation time period) to supply the production instruction to the above described production simulator, executing simulation for only the previously set time period (simulation time period) to determine a production schedule for a previously set time period (schedule determination time period), and setting a date and time immediately after the above described determined time period as a new schedule creation starting time and time to formulate a production schedule.

39. A production process control device comprising:

a production simulator that simulates a production process expressing a production state and a production constraint of the production process;

a mathematical expression model holding device that holds a mathematical expression model which uses a state equation created by acquiring information relating to creation of a production schedule to which attention is paid, and is a mathematical expression model expressing the production state and the production constraint of the above described production process in a mathematical expression; and

an optimization calculation device that performs optimization calculation processing by using a predetermined evaluation function for the above described mathematical expression model to calculate a production instruction for said production simulator,

wherein control of the production process is performed based on a simulation result obtained by repeating processing of calculating a feedback gain by the above described optimization calculation processing, calculating the production instruction by using the feedback gain and the production state to supply the production instruction to said production simulator to proceed with simulation, obtaining a new production state, and calculating a new production instruction based on the new production state.

40. A production process control device, comprising:

a production simulator that simulates a production process expressing a production state and a production constraint of the production process;

a mathematical expression model holding device that holds a mathematical expression model which is created by acquiring information relating to creation of a production schedule to which attention is paid, with a time period previously set from a schedule creation starting time of the above described production process (schedule creation time period) as a target, and is a mathematical expression model expressing the production state and the production constraint of the above described production process in a mathematical expression; and

an optimization calculation device that performs optimization calculation processing by using a predetermined evaluation function for the above described mathematical expression model, and calculates a production instruction for said production simulator,

wherein production control of the production process is performed based on a simulation result obtained by repeating processing of calculating the production instruction for a time period previously set from present time by the above described optimization calculation processing (instruction calculation time period) to supply the production instruction to the above described production simulator, executing simulation for only the

previously set time period (simulation time period) to determine a production schedule for a previously set time period (schedule determination time period), and setting a date and time immediately after the above described determined time period as a new schedule creation starting time and time to formulate a production schedule.

41. A method for controlling a production process by a production process control device having a production simulator that simulates a production process expressing a production state and a production constraint of the production process, a mathematical expression model holding device that holds a mathematical expression model which uses a state equation created by acquiring information relating to creation of a production schedule to which attention is paid, and is a mathematical expression model expressing the production state and the production constraint of the above described production process in a mathematical expression, and an optimization calculation device that performs optimization calculation processing by using a predetermined evaluation function for the above described mathematical expression model to calculate a production instruction for the above described production simulator,

wherein control of the production process is performed based on a simulation result obtained by repeating processing of calculating a feedback gain

by the above described optimization calculation processing, calculating the production instruction by using the feedback gain and the production state to supply the production instruction to the above described production simulator to proceed with simulation, obtaining a new production state, and calculating a new production instruction based on the new production state.

42. A method for controlling a production process using a production process control device having a production simulator that simulates a production process expressing a production state and a production constraint of the production process, a mathematical expression model holding device that holds a mathematical expression model which is created by acquiring information relating to creation of a production schedule to which attention is paid, with a time period previously set from a schedule creation starting time of the above described production process (schedule creation time period) as a target, and is a mathematical expression model expressing the production state and the production constraint of the above described production process in a mathematical expression, and an optimization calculation device that performs optimization calculation processing by using a predetermined evaluation function for the above described mathematical expression model, and calculates a production instruction for the above described

production simulator,

wherein production control of the production process is performed based on a simulation result obtained by repeating processing of calculating the production instruction for a time period previously set from present time by the above described optimization calculation processing (instruction calculation time period) to supply the production instruction to the above described production simulator, executing simulation for only a previously set time period (simulation time period) to determine a production schedule for a previously set time period (schedule determination time period), and setting a date and time immediately after the above described determined time period as a new schedule creation starting time and time to formulate a production schedule.

43. A computer program causing a computer to realize functions as a production simulator that simulates a production process expressing a production state and a production constraint of the production process, a mathematical expression model holding device that holds a mathematical expression model which uses a state equation created by acquiring information relating to creation of a production schedule to which attention is paid, and is a mathematical expression model expressing the production state and the production constraint of the above described production process in a mathematical

expression, and an optimization calculation device that performs optimization calculation processing by using a predetermined evaluation function for the above described mathematical expression model to calculate a production instruction for the above described production simulator,

wherein control of the production process is performed based on a simulation result obtained by repeating processing of calculating a feedback gain by the above described optimization calculation processing, calculating the production instruction by using the feedback gain and the production state to supply the production instruction to the above described production simulator to proceed with simulation, obtaining a new production state, and calculating a new production instruction based on the new production state.

44. A computer-readable recording medium recording a computer program causing a computer to realize functions as a production simulator that simulates a production process expressing a production state and a production constraint of the production process, a mathematical expression model holding device that holds a mathematical expression model which uses a state equation created by acquiring information relating to creation of a production schedule to which attention is paid, and is a mathematical expression model expressing the production state and the production constraint of the

above described production process in a mathematical expression, and an optimization calculation device that performs optimization calculation processing by using a predetermined evaluation function for the above described mathematical expression model to calculate a production instruction for the above described production simulator,

wherein control of the production process is performed based on a simulation result obtained by repeating processing of calculating a feedback gain by the above described optimization calculation processing, calculating the production instruction by using the feedback gain and the production state to supply the production instruction to the above described production simulator to proceed with simulation, obtaining a new production state, and calculating a new production instruction based on the new production state.

45. A computer program causing a computer to realize functions as a production simulator that simulates a production process expressing a production state and a production constraint of the production process, a mathematical expression model holding device that holds a mathematical expression model which is created by acquiring information relating to creation of a production schedule to which attention is paid, with a time period previously set from a schedule creation starting time of the above described production process (schedule

creation time period) as a target, and is a mathematical expression model expressing the production state and the production constraint of the above described production process in a mathematical expression, and an optimization calculation device that performs optimization calculation processing by using a predetermined evaluation function for the above described mathematical expression model, and calculates a production instruction for the above described production simulator,

wherein production control of the production process is performed based on a simulation result obtained by repeating processing of calculating the production instruction for a time period previously set from present time by the above described optimization calculation processing (instruction calculation time period) to supply the production instruction to the above described production simulator, executing simulation for only a previously set time period (simulation time period) to determine a production schedule for a previously set time period (schedule determination time period), and setting a date and time immediately after the above described determined time period as a new schedule creation starting time and time to formulate a production schedule.

46. A computer-readable recording medium recording a computer program causing a computer to realize functions as a production simulator that

simulates a production process expressing a production state and a production constraint of the production process, a mathematical expression model holding device that holds a mathematical expression model which is created by acquiring information relating to creation of a production schedule to which attention is paid, with a time period previously set from a schedule creation starting time of the above described production process (schedule creation time period) as a target, and is a mathematical expression model expressing the production state and the production constraint of the above described production process in a mathematical expression, and an optimization calculation device that performs optimization calculation processing by using a predetermined evaluation function for the above described mathematical expression model, and calculates a production instruction for the above described production simulator,

wherein production control of the production process is performed based on a simulation result obtained by repeating processing of calculating the production instruction for a time period previously set from present time by the above described optimization calculation processing (instruction calculation time period) to supply the production instruction to the above described production simulator, executing simulation for only the previously set time period (simulation time period)

to determine a production schedule for a previously set time period (schedule determination time period), and setting a date and time immediately after the above described determined time period as a new schedule creation starting time and time to formulate a production schedule.